NASA-EP-300

Educational Reference	
Teachers	Grades 7-12

National Aeronautics and
Space Administration
Office of Mission to Planet Earth

424577

LOOKING AT EARTH FROM SPACE

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P-17

DIRECT READOUT FROM ENVIRONMENTAL SATELLITES

This booklet was developed for NASA by WT Chen & Company, with special thanks to Mr. Charlie Davis of the Dallas Remote Imaging Group. Graphic design and editing by the Earth Science Support Office. January 1994.

CONTENTS

DIRECT READOUT

What is direct readout?

Direct readout is the capability to acquire information directly from meteorological satellites.

Data can be acquired from the National Aeronautics and Space Administration (NASA) -developed, National Oceanic and Atmospheric Administration (NOAA) -operated satellites, as well as from other nations' meteorological satellites.

How do I get direct readout?

By setting up a personal computer-based ground (Earth) station to receive satellite signals. The electronic satellite signals received by the ground station are displayed as images on the computer screen. Please see ground station configuration chart on pages 7-8.

How much does this cost?

A complete ground station, excluding the microcomputer, can be purchased for about $1500. By obtaining the data from the source (the satellites), an unlimited supply of data can be obtained without additional cost.

What kind of information can I get?

Images that display gradients of the Earth's topography and temperature, cloud formations, the flow and direction of winds and water currents, the formation of hurricanes, the occurrence of an eclipse, and a view of Earth's geography. Both visible and infrared images can be obtained.

What difference will this make in my classroom?

Direct readout provides students with a unique opportunity to acquire data first-hand from satellites. Students can participate in a complete hands-on scientific process: acquiring data from the source, processing and analyzing data, and making predictions.

Direct readout brings real-time information, dynamic technology, and a wealth of knowledge about the planet into the classroom. The acquired data can support a broad range of disciplines, such as: Earth science, physical science, oceanography, meteorology, biology, and space science. Inherent disciplines in this process, that can also be the focal point are: geography, and physics. Mathematics can be emphasized or minimized as preferred.

Where do I start?

Obtain the "Looking at Earth from Space" publications, especially the Training Manual, Teacher's Guide, and Global Change Teacher's Guide. See page 11.

Computer requirements are listed on pages 9-10. Perhaps your school already owns an appropriate computer, or has one it can upgrade.

Contact vendors for equipment specifications and prices. Many vendors offer a demonstration disk to requesters. See page 14.

Determine the type data you wish to receive. See the Satellite Systems on pages 3 - 6.

Check the list of contacts and resources for information and assistance. See pages 12-13, and page 15.

SATELLITE SYSTEMS

Environmental (weather) satellites are unmanned spaceships that carry a variety of sensors. They scan the Earth, and electronically transmit acquired information back to Earth. The electronic signals are received by environmental satellite ground stations that convert the signals into an image or picture of what the sensors saw from space.

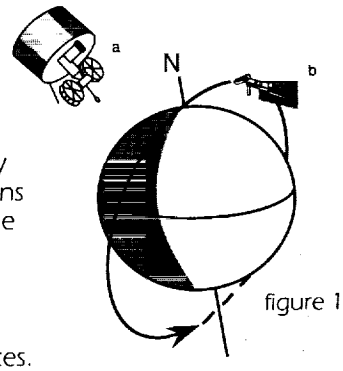


figure 1

Two types of environmental satellite systems provide direct readout services. The satellite systems are geostationary and polar-orbiting, named for their orbit types. By operating both kinds of satellites, a comprehensive view of local and worldwide weather is provided.

Geostationary

Geostationary or geosynchronous satellites orbit the Earth at a speed and altitude that enable them to continuously hover over one area of the Earth's surface. This provides constant coverage of that area.

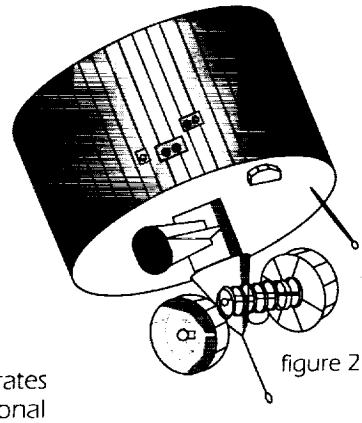


figure 2

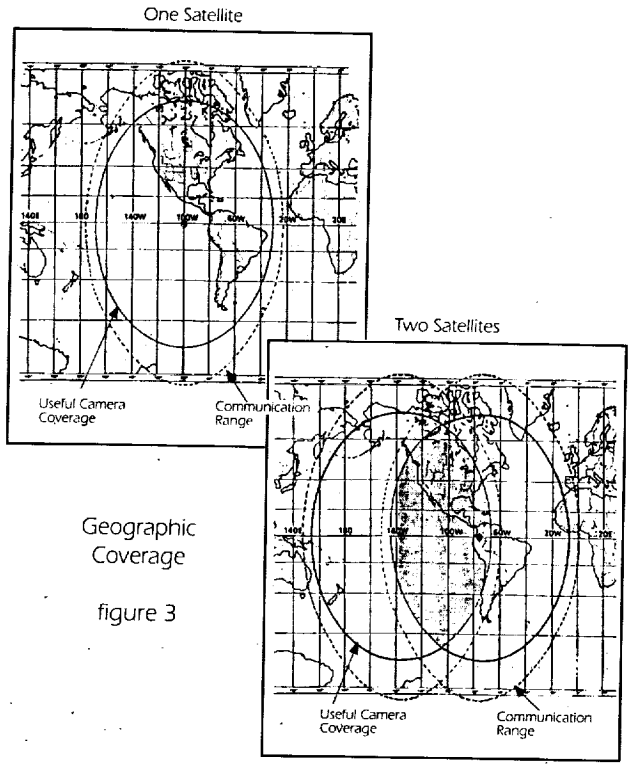
The United States operates Geostationary Operational Environmental Satellites (GOES) [figure 1 and figure 2) . From its orbit 22,238 miles above Earth, GOES views almost a third of Earth's surface and provides continuous western hemisphere coverage. Figure 3 shows the coverage provided by one- and two-satellite systems.

One of GOES communication functions is to provide Weather Facsimile (WEFAX) services, which can be received by low-cost ground stations. WEFAX data consists of retransmissions of processed images obtained by GOES satellites, as well as other meteorological data and images produced by polar-orbiting satellites.

WEFAX broadcasts on a fixed schedule with over 100 transmissions per 24 hour period. Included are visible and infrared images, weather charts, ice charts, and operational messages.

GOES also provides high resolution images. Those images, produced by an instrument called the Visible and Infrared Spin Scan Radiometer (VISSR), are the pictures presented on TV weather programs. VISSR image acquisition requires significantly more expensive equipment than does WEFAX.

GOES



Geographic Coverage

figure 3

Other nations also operate geostationary satellites. GMS is the Japanese Geostationary Meteorological Satellite, METEOSAT is Europe's geostationary weather satellite.

SATELLITE SYSTEMS

Polar-Orbiting

Polar-orbiting satellites [figure 1, page 3] orbit the Earth in a path that crosses almost directly over the poles. They were developed to provide real-time (as-it-happens) information about the Earth and its atmosphere.

By operating in sun-synchronous orbit, (500-670 miles above Earth) polar orbiters cross the equator and each latitude at the same time each day. This means data is provided within a consistent frame of reference.

U.S. polar orbiters are TIROS satellites (figure 4), which provide low-resolution imagery called Automatic Picture

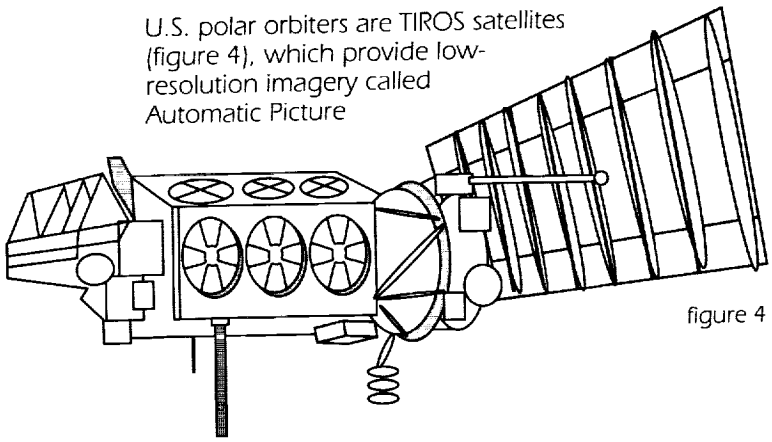


figure 4

Transmission (APT). APT is real-time data receivable whenever an APT- equipped satellite passes within radio range of an APT ground station.

The video images obtained by the polar-orbiters are transmitted as an AM signal corresponding to the light and dark areas of Earth as seen by the sensors. The loudest portion of the signal represents the lightest portion of the image, the lowest tones represent the darkest portion of the image, the middle tones represent the gray areas.

The APT signal is transmitted continuously from satellites. This results in a strip of image as long as the transmission is received and as wide as the scanning instrument is designed to cover. The image obtained during a normal 14-minute reception period is approximately 1700 miles long. For example, a ground station in Baltimore will acquire an Eastern

U.S. image bordered by Cuba (S), Quebec (N), Minnesota (W), and the Atlantic Ocean (E) from a typical satellite pass.

APT signals can be saved for reuse, either with a tape recorder or in computer memory.

Polar-orbiters also provide High Resolution Picture Transmission (HRPT) services. These digital signals are received by higher-cost HRPT ground stations and provide resolution of 1.1 km, as compared to the 4 km APT resolution.

Polar-orbiters must be tracked to identify their location at a particular time. Ground station users can use computer software programs or mathematical calculations to determine both their location, and the optimal pass times (when the satellite signals are most accessible to the receiving equipment).

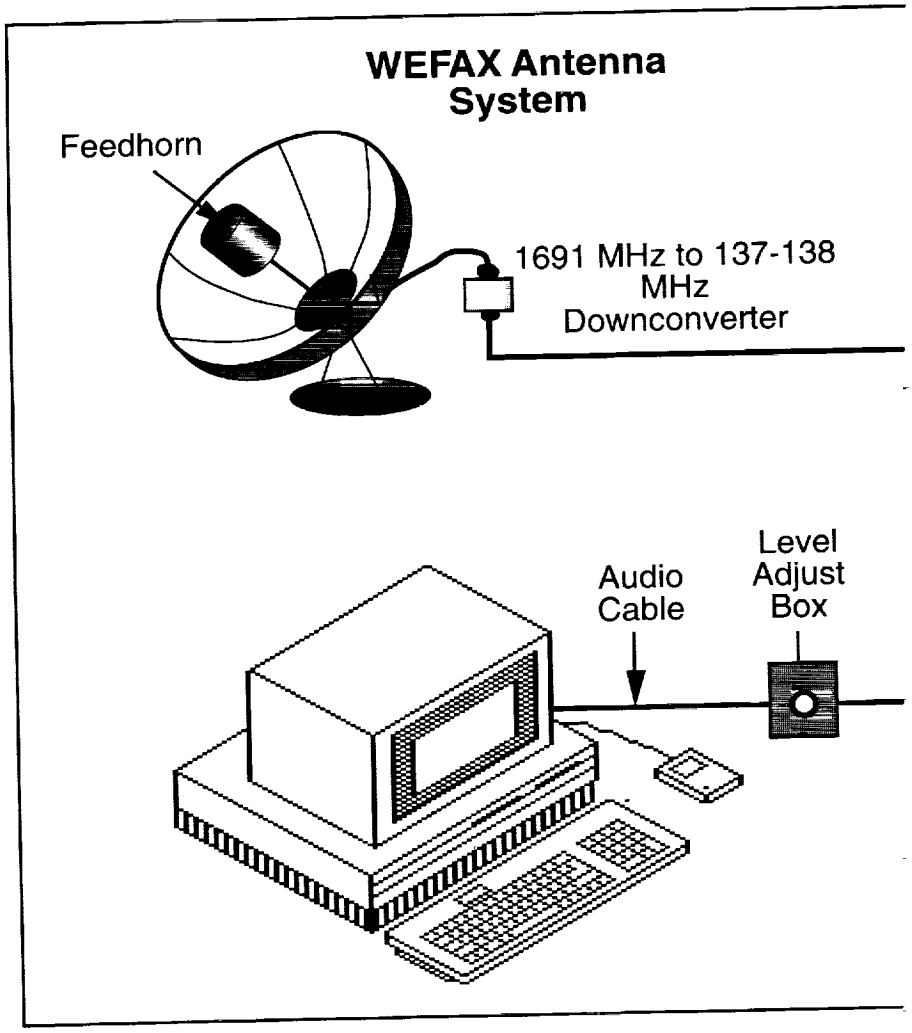
Many teachers find the polar-orbiter systems preferable for classroom use because of the slightly less expensive equipment, the inherent educational value of tracking and predicting orbital paths, and the real-time data. The ultimate classroom ground station receives both polar-orbiter and geostationary data, providing both local and national information.

NASA launched the first meteorological satellite in 1960, and continues to design and launch U.S. meteorological spacecraft. NOAA establishes the observational requirements of the satellites, and operates the satellite after launch. Nations such as Russia and China also operate weather satellites and provide data accessible to ground station users.

Resolution

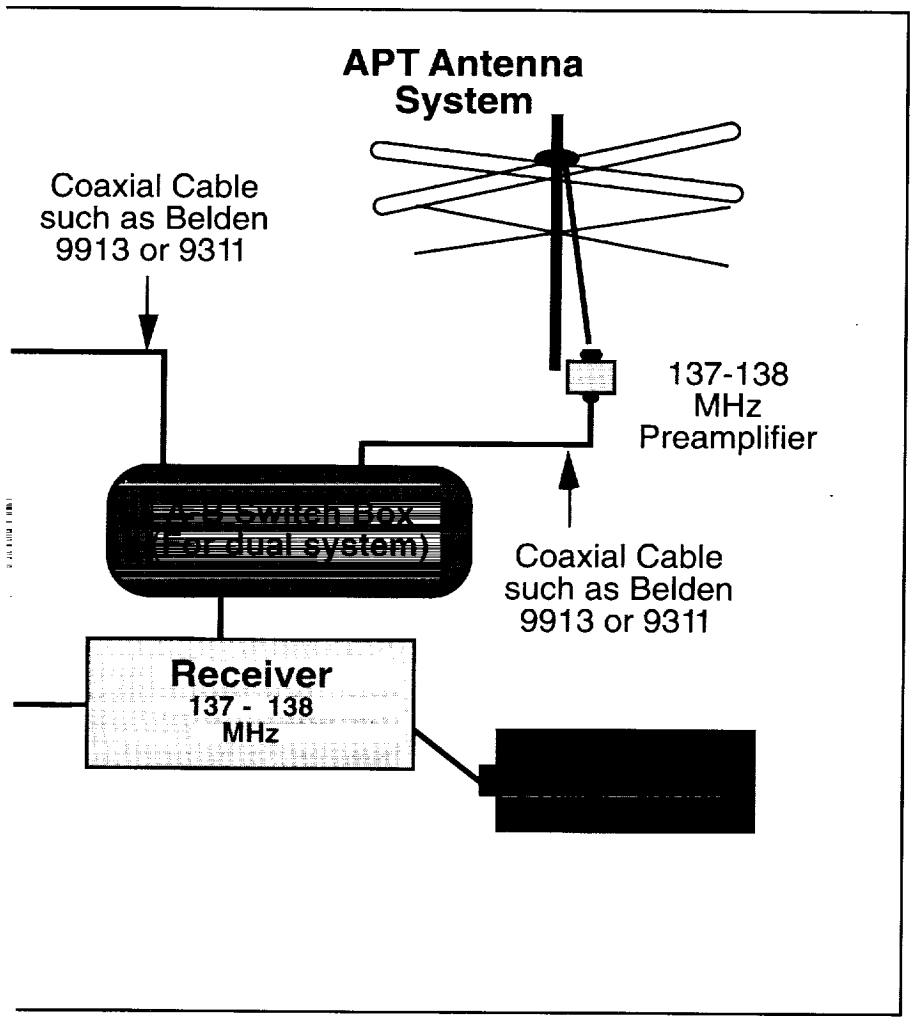
Resolution indicates the area represented by each picture element–pixel–in an image. The lower the number, the higher the resolution (detail). For example, compare a state map and a national map, each printed on the same size paper. The state map will have the higher resolution (greater detail) since each square inch has to represent far less land than the one of the entire country.

Direct Readout Ground Station Configuration



WEFAX A WEFAX system including a satellite dish antenna, feedhorn, downconverter, receiver, level adjust box, cables, power supply and computer.*

APT An APT system including an antenna, preamplifier, receiver, power supply, level adjust box, computer, and cables.*



Dual *A dual system (APT and WEFAX) ground station may require all of the above, although even this basic set-up will vary among manufacturers.**

*Check with vendor, some of the newest systems have combined components.

COMPUTER REQUIREMENTS

Recommended Configuration for IBM/Compatible APT Systems

Computer

- 386 or 486/33 MHz computer 64K cache* w/ 4 MB RAM*
- SVGA monitor 1024 x 768 x 256 .28 dot pitch non-interlaced
- SVGA graphics card with 1 MB RAM 1024 x 768 x 265
- 200 watt power supply
- Standard, mid-sized case
- I/O card with 1 serial port and 1 parallel printer port
- MS DOS installed
- 120 MB IDE hard drive
- At least one floppy drive, either 5-1/4 inch or 3-1/2 inch
- IDE hard drive/floppy drive controller
- 101 keyboard enhanced
- Power strip with surge suppression
- Microsoft compatible mouse
- Math co-processor (see note)
- 2400 to 9600 baud modem (see note)
- VESA support

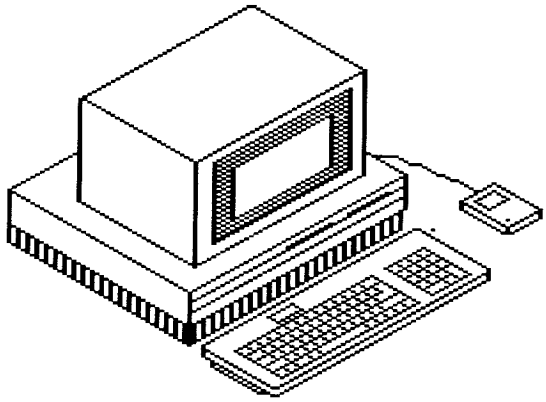
* one vendor recommends 256 cache with 8 MB RAM

Math Co-processors

A math co-processor will greatly speed up satellite tracking programs as well as any other program that utilizes floating point arithmetic. You can get by without it, but you may regret it. (486 DX computers have a built-in math co-processor.)

Modem

A 2400 to 9600 baud modem with cables will enable the user to obtain Keplerian elements (see page 15) from a bulletin board source.



Recommended Computer Configuration for Apple APT Systems

Apple IIGS, check system memory requirements.

Recommended Computer Configuration for MAC APT Systems

Any MAC II or better will work, that is, any MAC using the new bus-based card system. MAC LC II cannot be upgraded to provide support—at least not according to the vendors we've spoken with. Do check with the vendors though.

LOOKING AT EARTH FROM SPACE

NASA's Office of Mission to Planet Earth is responsible for mounting a global-scale examination of the Earth to study the interaction of all the environmental factors—air, water, land, biota—that make up the Earth system. Satellites carrying specialized instruments will make observations of environmental variables and climate. A complex data and information system will enable access to, and analysis and storage of the data acquired. All of this will increase our understanding of the Earth system and how humans are impacting it.

The **MA**ryland **P**ilot Earth **S**cience and Technology Education **NET**work (MAPS-NET) is a NASA pilot project to enrich middle and high school curriculum through the use of remote-sensing technology, meteorology, and by introducing key Earth system science concepts. MAPS-NET is a state-wide approach to direct readout, providing graduate-level training and extensive support for participating teachers. A series of publications entitled *Looking at Earth from Space* is being prepared by MAPS-NET for NASA with publication winter–fall 1994.

L

ooking at Earth from Space

This series includes: a training manual to help teachers use an Earth station and understand the atmospheric conditions displayed in the images they acquire (fall 1994); a direct readout teacher's resource guide containing lesson plans for grades 4-12 (fall 1994); a dictionary of terms (spring 1994); a teacher's guide to global change (summer 1994); and an equipment and vendors guide (spring 1994), which provides information about selecting and purchasing ground station equipment, and this introduction to direct readout.

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or additional information please contact:

Dr. Gerald Soffen, Director, University Programs
Goddard Space Flight Center, Code 160
Greenbelt Road
Greenbelt, Maryland 20771

Contact your NASA Teacher Resource Center to obtain "Looking at Earth from Space" publications. See page 12.

RESOURCES

NASA Teacher Resource Centers offer a variety of print materials for distribution, and copyright-free slides and video tapes that may be duplicated.

If you live in:	**Contact:**
AK, AZ, CA, HI, ID, MT, NV, OR, UT, WA, WY	NASA Teacher Resource Center NASA Ames Research Center, Mail Stop TO-25 Moffett Field, CA 94035 (415) 604-3574
CT, DE, DC, ME, MD, MA, NH, NJ, NY, PA, RI, VT	NASA Teacher Resource Laboratory NASA Goddard Space Flight Center, Mail Code130.3 Greenbelt, MD 20771 (301) 286-8570
CO, KS, NE, NM, ND, OK, SD, TX	NASA Teacher Resource Room NASA Johnson Space Center, Mail Code AP-4 Houston, TX 77058 (713) 483-8696
FL, GA, PR, VI	NASA Educators Resource Laboratory NASA Kennedy Space Center, Mail Code ERL Kennedy Space Center, FL 32899 (407) 867-4090
KY, NC, SC, VA, WV	Virginia Air and Space Museum NASA Teacher Resource Center 600 Settler's Landing Road Hampton, VA 23669 (804) 727-0800
IL, IN, MI, MN, OH, WI	NASA Teacher Resource Center, NASA Lewis Research Center, Mail Stop 8-1 21000 Brookpark Road Cleveland, OH 44135 (216) 433-2017
AL, AR, IA, LA, MO, TN	NASA Teacher Resource Center Alabama Space and Rocket Center Huntsville, AL 35807 (205) 544-5812
MS	NASA Teacher Resource Center NASA John C. Stennis Space Center, Building 1200 Stennis Space Center, MS 39529 (601) 688-3338J
JPL Activities	NASA Teacher Resource Center JPL Educational Outreach Jet Propulsion Laboratory, Mail Stop CS-530 4800 Oak Grove Drive Pasadena, CA 91109 (818) 354-6916

RESOURCES

NASA Space Link

Space Link Administrator
NASA Marshall Space Flight Center, Mail Code CA21
MSFC, Alabama 35812
(205) 544-0038

NASA Space Link is an electronic information system for educators accessible via modem or internet. By modem: 205-895-0028, data format 8-none-1. Internet address: 192.149.89.61

NASA Office of Mission to Planet Earth

NASA Headquarters
Code Y
Washington, DC 20546-0001

MTPE publications and data can be requested from this address.

NOAA Educational Affairs

1825 Connecticut Avenue, NW, Suite 627
Washington, DC 20235
(202) 606-4380
FAX (202) 606-4425

Educational materials, including copies of the Educator's Guide For Building and Operating Environmental Satellite Receiving Stations (free).

National Air and Space Museum

Education Resource Center (ERC)
MRC 305, NASM
Washington, DC 20560
(202) 786-2109

For teachers of grades K-12, the ERC offers educational materials about aviation, space exploration, and the Museum's collections, including curriculum packets, videotapes, slides, filmstrips, and computer software. Free Skylines newsletter is published three times annually. Send your request on school stationery to Skylines at the ERC address.

VENDORS

MAPS-NET is not affiliated with any vendor. The following list is provided for your convenience:

Amsat
PO Box 27
Washington, DC 20044
v (301) 589-6062
f (301) 608-3410

Clear Choice Education Products
PO Box 745
Helen, Georgia 30545
v 800 533-5708
f (706) 865-7808
(education materials only)

ERIM
Earth Observation Group
PO Box 134001
Ann Arbor, Michigan 48113
v (313) 994-1200, ext 3350
f (313) 668-8957

Fisher Scientific*
4901 West LeMoyne Street
Chicago, Illinois 60651
v 800 955-1177
f (312) 378-7174

GTI*
1541 Fritz Valley Road
Lehighton, Pennsylvania 18235
v (717) 386-4032
f (717) 386-5063

Lone Eagle Systems Inc
5968 Wenninghoff Road
Omaha, Nebraska 68134
v (402) 571-0102
f (402) 572-0745

Marisys Inc*
131 NW 43rd Street
Boca Raton, Florida 33431
v (407) 361-0598
f (407) 361-0599

MultiFAX
143 Rollin Irish Road
Milton, Vermont 05468
v (802) 893-7006
f (802) 893-6859

Northern Video Graphics, Inc.
511 11th Avenue South, Box 92
Minneapolis, Minnesota 55415
v (612) 338-6589

OFS Weatherfax
6404 Lakerest Court
Raleigh, North Carolina 27612
v (919) 847-4545
f (919) 847-4545

Quorum Communications, Inc
8304 Esters Boulevard, Suite 850
Irving, Texas 75063
v (800) 982-9614
v (214) 915-0256
f (214) 915-0270
BBS (214) 915-0346

Satellite Data Systems, Inc.
800 Broadway Street,PO Box 219
Cleveland, Minnesota 56017
v (507) 931-4849
f (same as voice number)

Software Systems Consulting
615 S. El Camino Real
San Clemente, California 92672
v (714) 498-5784
f (714) 498-0568

Tri-Space Inc.
PO Box 7166
McLean, Virginia 22106-7166
v (703) 442-0666
f (703) 442-9677

U.S. Satellite Laboratory
8301 Ashford Blvd., Suite 717
Laurel, Maryland 20707
v (301) 490-0962
f (301) 490-0963

Vanguard Electronic Labs
196-23 Jamaica Avenue
Hollis, New York 11423
v (718) 468-2720
f (718) 468-2720

* Equipment manufacturer, invited to submit equipment for review in the guide but did not participate.

KEPLERIAN ELEMENTS

Keplerian Elements, or satellite orbital elements, are the group of numbers required to define a satellite orbit. The elements are a critical component of satellite tracking and essential to APT system-users for identifying optimal signal reception. Keplerian elements can be obtained by modem, at no charge other than the long distance phone fees, from the following electronic bulletin boards.

MAPS-NET
Bulletin Board
410-239-4247
Hampstead, MD
SYSOP: Mr. Charlie Davis
24 hours
14400/9600/2400/1200 baud
8 bit NO parity 1 stop

DatalinkRBBS System
Dallas Remote Imaging
Group (DRIG)
214-394-7438
SYSOP: Dr. Jeff Wallach
24 hours
14400/9600/2400/1200 baud
8 bit NO parity 1 stop

Dial the BBS and login.

Type "D" for download, type "BULLET90" as the file to download, open a ZMODEM file transfer mode with your telecommunications software. (The file name is always called BULLET90.) This will transfer the NASA 2-line elements to a file on the users computer. Log out of the BBS. (These instructions apply only to MAPS-NET and DRIG BBS.)

NOAASAT
Bulletin Board
301-763-8500
SYSOP: Jim Green
24 hours
2400/1200 baud
8 bit NO parity 1 stop

Celestial RCP/M
513-427-0674
Fairborn, OH
SYSOP: Dr. T.S. Kelso
24 hours
9600/2400/1200 baud
8 bit NO parity 1 stop

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